APPENDICES

APPENDICES

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Appendix 1 - Glossary of Terms and Acronyms

Adaptation: This is the response to the changes that are occurring because of the excessive human-induced GHGs that have been collecting in the atmosphere for the past 100 years. While mitigation strategies are similar for most areas of the United States, the way that a community chooses to adapt to a changing climate is very specific for each region.

Baseline: The baseline serves as a reference point to assess changes in greenhouse gas emission from year to year. According to the California Air Resources Board (CARB), in general, Baseline Actual Emissions as of a particular date shall equal the average rate, in tons per year, at which the unit actually emitted the pollutant during a two-year period which precedes the particular date and which is representative of normal source operation. For purposes of creating the baseline emissions, local governments estimate emissions from government operations and community-level.

Business-As-Usual (BAU): A scenario used for the projection of greenhouse gas emissions at a future date based on current technologies and regulatory requirements in absence of other reductions.

Carbon Dioxide (CO_2): This is the reference gas against which other greenhouse gases are measured and therefore has a Global Warming Potential of 1. It is naturally occurring and is also a primary by-product from combustion of fossil fuels and other industrial and agricultural processes.

Carbon Dioxide Equivalent (CO_2e): This is a common unit for normalizing greenhouse gases with different levels of heat trapping potential. For carbon dioxide itself, emissions in tons of CO_2 and tons of CO_2e are the same, whereas for nitrous oxide and methane, stronger greenhouse gases, one ton of emissions is equal to 310 tons and 21 tons of CO_2e respectively.

Chlorofluorocarbons (CFCs): A family of inert, nontoxic, and easily liquefied chemicals used in refrigeration, air conditioning, packaging, insulation, or as solvents and aerosol propellants. Because CFCs are not destroyed in the lower atmosphere, they drift into the upper atmosphere, where their chlorine components destroy the ozone layer.

The California Environmental Quality Act (CEQA): This was a California statute passed in 1970, shortly after the United States federal government passed the National Environmental Policy Act (NEPA), to institute a statewide policy of environmental protection. CEQA does not directly regulate land uses, but instead requires state and local agencies within California to follow a protocol of analysis and public disclosure of environmental impacts of proposed projects and adopt all feasible measures to mitigate those impacts.

Climate: This is typically defined as the "average weather," or more rigorously, as the statistical description in terms of the average and variability of weather over a period of time ranging from months to thousands of years. These variables are most often temperature, precipitation, and wind. Climate can also refer to the global climate system.

Climate Action Plan: A description of the measures and actions that an organization will take to reduce greenhouse gas emissions and achieve an emissions reduction target. Most plans include a description of existing and future year emissions; a reduction target; a set of

measures, including performance standards that will collectively achieve the target; and a mechanism to monitor the plan.

Climate Change: Climate change refers to any significant change in measures of climate (such as temperature, precipitation, or wind) lasting for an extended period (decades or longer). Climate change results from: 1) natural factors, such as changes in the sun's intensity or slow changes in the Earth's orbit around the sun; 2) natural processes within the climate system (e.g. changes in ocean circulation); and 3) human activities that change the atmosphere's composition (e.g. through burning fossil fuels) and the land surface (e.g. deforestation, reforestation, urbanization, desertification, etc.).

Co-Benefit: Multiple, ancillary benefits of a policy, program or intervention. Many climate change mitigation measures designed to reduce greenhouse gas emissions have other benefits such as energy and cost savings.

Corporate Average Fuel Economy (CAFE): The CAFE standards were originally established by Congress for new automobiles, and later for light trucks, in Title V of the Motor Vehicle Information and Cost Savings Act. Under CAFE, automobile manufacturers are required by law to produce vehicles with composite sales-weighted fuel efficiency, which cannot be lower than the CAFE standards in a given year. Standardized tests are used to rate the fuel economy of new vehicles.

Discount Rate: The choice of the discount rate for evaluating the net present value of these investments can be critical in determining whether or not to implement the associated mitigation efforts. By way of example, the Stern Review on the Economics of Climate Change utilizes a social discount rate of 1.4% for evaluating projects associated with climate change.

Energy Efficiency: This relates to a change in behavior in that the same function can be accomplished with less electricity. This usually requires newer equipment (such as televisions), different types of lighting (such as CFL bulbs) and other technology changes.

Energy Conservation: This is a typical practice using what you have more efficiently, such as shutting off the light or only using the dishwasher when it is full.

Emissions: The release of a substance (usually a gas when referring to the subject of climate change) into the atmosphere.

Emissions Factor: A set of coefficients used to convert data from electricity, natural gas, fuel and waste to calculate GHG emissions. These emission factors are the ratio of emissions of a particular pollutant (e.g., carbon dioxide) to the quantity of the fuel used (e.g., kilograms of coal). For example, when burned, 1 ton of coal = 2.071 tons of CO_2.

Forecast Year: Any future year in which predictions are made about emissions levels based on growth multipliers applied to the base year.

Global Warming: Global warming is an average increase in the temperature of the atmosphere near the Earth's surface and in the troposphere, which can contribute to changes in global climate patterns. Global warming can occur from a variety of causes, both natural and human induced. In common usage, "global warming" often refers to the warming that can occur as a result of increased emissions of greenhouse gases.

Global-warming Potential (GWP): This is a relative measure of how much heat a greenhouse gas traps in the atmosphere. It compares the amount of heat trapped by a certain mass of the gas in question to the amount of heat trapped by a similar mass of carbon dioxide. A GWP is calculated over a specific time interval, commonly 20, 100 or 500 years. GWP is expressed as a factor of carbon dioxide (whose GWP is standardized to 1). For example, the 20 year GWP of methane is 72, which means that if the same mass of methane and carbon dioxide were introduced into the atmosphere, that methane will trap 72 times more heat than the carbon dioxide over the next 20 years.

Greenhouse Effect: The build-up of heat in the atmosphere (troposphere) near the Earth's surface due to infrared radiation from the sun being absorbed by water vapor, carbon dioxide, ozone, and several other gases. This heat is then re-radiated back toward the Earth's surface. As atmospheric concentrations of these greenhouse gases rise, the average temperature of the lower atmosphere gradually increases.

Greenhouse Gas: Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include, but are not limited to, water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (NO_2), chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), ozone (O_3), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

Heating, Ventilation, and Air Conditioning (HVAC): These are mechanical systems that control the ambient environment (temperature, humidity, air flow and air filtering) of a building.

Hydrofluorocarbons (HFCs): Man-made compounds containing hydrogen, fluorine, and carbon that were developed as an alternative to ozone-depleting substances for industrial, commercial, and consumer products. HFCs do not have the potential to destroy stratospheric ozone, but they are still powerful greenhouse gases.

Intergovernmental Panel on Climate Change (IPCC): The IPCC was established jointly by the United Nations Environment Program and the World Meteorological Organization in 1988. The purpose of the IPCC is to assess information in the scientific and technical literature related to all significant components of the issue of climate change. The IPCC draws upon hundreds of the world's expert scientists as authors and thousands as expert reviewers. Leading experts on climate change and environmental, social, and economic sciences from some 60 nations have helped the IPCC to prepare periodic assessments of the scientific underpinnings for understanding global climate change and its consequences. With its capacity for reporting on climate change, its consequences, and the viability of adaptation and mitigation measures, the IPCC is also looked to as the official advisory body to the world's governments on the state of the science of the climate change issue. For example, the IPCC organized the development of internationally accepted methods for conducting national greenhouse gas emission inventories.

Methane (CH_4): A hydrocarbon that is a greenhouse gas with a global warming potential most recently estimated at 23 times that of carbon dioxide (CO_2). Methane is produced through anaerobic (without oxygen) decomposition of waste in landfills and sewage treatments, animal digestion, decomposition of animal wastes, production and distribution of natural gas and petroleum, coal production, and incomplete fossil fuel combustion.

Measures: Any action taken to reduce GHG emissions.

Mitigation: This is putting in place enforceable plans, policies, and programs to reduce GHG emissions now in order to slow the rate of increase in the atmosphere. Successful mitigation at local, national and international levels will reduce the impacts of a changing climate for future generations. This is the legacy we leave.

Metric Ton (MT): Common international measurement for the quantity of greenhouse gas emissions. A metric ton is equal to 2205 lbs. or 1.1 short tons.

Mixed-Use: In a land-use planning context, a project that has at least three of the following amenities within a ¼ mile radius: 1) residential development, 2) retail and/or commercial development, 3) park, and 4) open space. Mixed-use developments encourage walking and other non-auto modes of transport from residential to office/commercial locations. The project should minimize the need for external vehicle trips by including services and facilities for day care, banking/ATM, restaurants, vehicle refueling, and shopping.

Natural Gas: This is the typical fuel used in new power generating facilities in California. Underground deposits of gases consist of 50 to 90% methane and small amounts of heavier gaseous hydrocarbon compounds such as propane and butane.

Perfluorocarbons (PFCs): Potent greenhouse gases that accumulate in the atmosphere and remain there for thousands of years. Aluminum production and semiconductor manufacture are the largest known man-made sources of perfluorocarbons.

Risk: Denotes the result of the interaction of physically defined hazards with the properties of the exposed systems - i.e., their sensitivity or social vulnerability. Risk can also be considered as the combination of an event, its likelihood and its consequences - i.e., risk equals the probability of climate hazard multiplied by a given system's vulnerability.

Resiliency: When referring to natural systems, the amount of change a system can undergo without changing state. When referring to human systems, the term "resiliency" can be considered as a synonym of adaptive capacity. This is determined by the degree to which the social system is capable of organizing itself to increase its capacity for learning from past disasters for better future protection and to improve risk reduction measures.

Sector: A term used to describe emission inventory source categories for greenhouse gases based on broad economic sectors.

Target Year: The year by which the emissions reduction target should be achieved.

Transit Oriented Development (TOD): A moderate- to high-density development located within ¼ mile of a major transit stop, generally with a mix of residential, employment, and shopping opportunities. TOD encourages walking, bicycling, and transit use without excluding the automobile.

Vehicles Miles Traveled (VMT): This unit measures the aggregate mileage traveled by all vehicles in a specific location. VMT is a key measure of street and highway use. Reducing VMT is often a major objective in efforts to reduce vehicular congestion and achieve air quality goals. The transportation sector is the top GHG emitter in California, contributing roughly 40% of all California emissions. Poor fuel efficiency and high vehicle miles traveled (VMT) are primary contributors to transportation sector GHG emissions. Meeting California's GHG emissions reduction goals requires reductions in both per-mile emissions (often measured in as

a vehicle's miles per gallon performance) and vehicle miles traveled. Fuel efficiency has been addressed historically by the federal Corporate Average Fuel Economy (CAFE) standards, and California has passed its own legislation regulating GHG emissions from vehicles. The number of miles traveled has ramifications on insurance premiums, but there has not been and likely will not be any legislative action to curb VMT even though it is growing at a much faster rate than population or the economy.

Vulnerability: The degree to which systems affected by climate change are susceptible to and unable to cope with adverse impacts.

Acronyms

AB - Assembly Bill

APCD – Air Pollution Control District (County of San Diego)

CACP - Clean Air and Climate Protection Software

CAP - Climate Action Plan

CAPPA - Climate and Air Pollution Planning Assistant

CARB - California Air Resources Board

CEC - California Energy Commission

CEQA - California Environmental Equality Act

CH_4 - Methane

CO_2 - Carbon dioxide

CMAP – Climate Mitigation and Adaptation Plan (City of San Diego)

CO_2e - Carbon dioxide equivalent

EPA - U.S. Environmental Protection Agency

GHG - Greenhouse gas

HFC - Hydrofluorocarbons

HVAC - Heating, ventilating, and air conditioning

IPCC - Intergovernmental Panel on Climate Change

KWh - Kilowatt-hours

LCFS - Low Carbon Fuel Standard

MMT - Million metric tons

MW - Megawatt

NO_2 - Nitrous oxide

PPM - Parts per million

SANDAG – San Diego Association of Governments

SB - Senate Bill

TOD - Transit oriented development

USGBC - U.S. Green Building Council

VMT - Vehicle miles traveled

Appendix II: Methodology for Estimating GHG Reductions

This document provides information about the data, methodologies, and sources used to estimate the greenhouse gas reductions associated with the measures included in the City of San Diego Climate Mitigation and Adaptation Plan (CMAP). Calculations were done for a series of city-based measures leading to GHG emissions reductions from electricity and natural gas, on-road transportation, land use and waste. Table 1 provides a summary of all the CMAP measures and their contribution to the overall reduction.

Table 1. Summary Table of CMAP Mitigation Measures

LOCAL MEASURES	2020		2035	
	MT CO2e Reduction	% of total Reduction	MT CO2e Reduction	% of total Reduction
Energy				
Residential Efficiency Retrofits	52,464	1%	132,386	4%
Commercial Efficiency Retrofits	20,646	1%	196,118	4%
Commercial Retrocommissioning	20,646	1%	58,835	1%
New Construction Efficiency	23,895	1%	-	0%
Residential Solar Water Heaters	9,596	0%	26,652	1%
Comercial Solar Water Heating	3,327	0%	12,434	0%
Clean and Efficient Distributed Generation	118,331	3%	318,252	5%
Water Use Efficiency	46,684	1%	39,469	3%
City Facility Efficiency Retrofits	13,222	0%	18,634	0%
Transportation				
Mass Transit	105,613	3%	119,649	3%
Bicycle Infrastructure	17,194	0%	38,522	1%
Parking - reduce spaces	30,782	1%	51,058	1%
Parking - preferred parking for Evs	42,621	1%	70,696	1%
Parking Increased fees	110,474	3%	130,158	2%
City Share of SB 375 Reductions (includes telecommute, carpool, vanpool, buspool, bottleneck relief, HOV/HOT lanes)	192,663	5%	710,413	6%
Signal timing and roundabouts	3,571	0%	4,761	0%
EV use	228,321	6%	631,799	5%
Convert municipal fleet to EV	13,160	0%	23,688	0%
Land Use				
Smart growth - population density	69,062	2%	65,279	2%
Waste				
Divert Trash and Capture Landfill and Waste	523,090	13%	656,668	13%
Total Local Measures	**1,645,362**	**41%**	**3,305,473**	**49%**

STATE/FEDERAL MEASURES	2020		2035	
	MT CO2e Reduction	% of total Reduction	MT CO2e Reduction	% of total Reduction
Energy				
Renewable Portfolio Standard	593,765	15%	722,734	11%
Transportation				
Pavley I	1,190,930	30%	2,146,749	21%
LCFS	563,206	14%	550,639	11%
CARB Tire Pressure Program	30,670	1%	26,201	0%
CARB HDV Aerodynamics	9,970	0%	11,083	0%
Total State/Federal Measures	**2,388,541**	**59%**	**3,457,406**	**51%**
TOTAL GHG REDUCTIONS	**4,033,903**	**100%**	**6,762,879**	**100%**

COMMON ASSUMPTIONS AND SOURCES

A set of common assumptions and sources was used to calculate emissions reductions for the CMAP measures.

Electric/Natural Gas Measures

The following assumptions were used in calculating greenhouse gas reductions for measures related to electric and natural gas.

Common Assumptions for Electric and Natural Gas Measures

- **Greenhouse Gas Intensity of Electricity** – The calculations include a dynamic greenhouse gas intensity of electricity in pounds per megawatt-hour (lbs/MWh). For example, as the percentage of electricity provided by renewable energy sources increases the greenhouse gas intensity of electricity falls. Consequently, each reduction in energy use yields a smaller greenhouse gas reduction. This calculation also includes the effects of increased electricity use for electric vehicles, which results in a reduction in emissions in the transportation sector and an increase in emissions in the electric sector.
- **Transmission Losses** – All electricity values include transmission losses of 7.5%.
- **Allocation of Energy Use in the Residential Sector** – The CMAP estimates assume that the total energy budget of the average residential unit is comprises 46% electricity use and 54% natural gas use.
- **Allocation of Energy Use in the Commercial Sector -** The CMAP estimates assume that the total energy budget of the average residential unit is comprises 70% electricity use and 30% natural gas use.

<u>Common Sources for Electric and Natural Gas Measures</u>

- Kavalec, Chris and Tom Gorin, 2009. California Energy Demand 2010-2020, Adopted Forecast. California Energy Commission. CEC-200-2009-012-CMF, available at http://www.energy.ca.gov/2009publications/CEC-200-2009-012/index.html.

On-Road Transportation

<u>Common Assumptions for Transportation Measures</u>

- **Vehicle Miles Traveled** (VMT)– VMT data was provided by the City of San Diego for the years 1990, 2004, 2007, 2008 and 2009. VMT forecasts for 2010, 2020 and 2035 were made on the basis of the regional planning agency's (SANDAG) population growth forecast for the City.
- **EMFAC Model 2007** and **Pavley I and Low Carbon Fuel Standard Post Processor Version I**– EMFAC 2007 is an Emissions Factors model used California-wide by its regional transportation planning agencies to calculate air pollutants, including carbon emissions, from all on-road vehicles on all roads. EMFAC 2007 combines tested vehicle emission rate data with regional vehicle activity to provide greater accuracy for regional emissions. We used the EMFAC 2007 model to obtain the business as usual GHG emissions for the region using SANDAG's local input data files for 2020 and 2035. The output emissions data were fed into the California Air Resources Board (CARB) Post Processor to obtain CO_2 reduction amounts in the region. The regional CO_2 reductions from the Post Processor reflect changes expected from federal and state mandates in 2020 and 2035: the Pavley I standards (equivalent to mpg changes in CAFE), and the state Low Carbon Fuel Standard (LCFS).
- **Greenhouse Gas Intensity** – Dividing the regional CO_2e by the regional system wide VMT provided the CO_2e/VMT emissions factor, a greenhouse gas intensity factor, for the region, with and without the Pavley I and Low Carbon Fuel Standard reductions. This factor was further adjusted to account for miles driven by electric vehicles of 4% in 2020, and 11% EV in 2035. The effect of this (California Energy Commission) forecasted increased electric vehicles miles in 2020 and 2035 is to further reduce the carbon intensity of vehicle emissions but this is offset to some extent by an increase in the electricity sector emissions. It was assumed that the regional CO_2e/VMT was representative of the City's CO_2e/VMT. This CO_2e/VMT was used for the calculation of the GHG reductions from those city measures that affect VMT. Because the carbon content of the fuel mix decreases with time, for example due to the state's Low Carbon Fuel Standard, the carbon intensity per mile also decreases. Consequently, with time, any future measure yields a proportionally

smaller greenhouse gas reduction. The CO2e/VMT factors used for the measures are provided in Table 2.

Table 2 Greenhouse Gas Intensity of Vehicle Miles Traveled

Year	CO2e/VMT	Comment
2010	5.04E-04	Business-as-Usual Value
2020	3.71E-04	LCFS target met, Pavley I met, 4% EV miles.
2035	3.08E-04	LCFS target 2020 met, Pavley I met, 11% EV miles

Measures that depend on reduction in fuel consumption were converted to CO2e reductions using an average factor of 0.01 metric tons per gallon.

- **Business-as-Usual (BAU) Projection** – The BAU CO2e projection for on-road transportation derives from the SANDAG EMFAC forecast of the VMT for the City and the BAU carbon intensity per VMT in the region in the target year 2020 or 2035.

Sources

- EMFAC 2007 is an EPA approved model used by California to assess effectiveness of its vehicular emissions, available at http://www.arb.ca.gov/msei/documentation.htm. EMFAC Series 12 input files were provided by SANDAG and used in CARB's Post Processor. The Post Processor is available at: http://www.arb.ca.gov/cc/sb375/tools/postprocessor.htm.
- Elasticity data for the calculation of VMT reductions from local measures and price effects were obtained from: Reid Erwing and Robert Cervero (2010): Travel and the Built Environment, Journal of the American Planning Association 76:3, 265-294; and, Victoria Transport Policy Institute, Transportation Elasticities, available at: http://www.vtpi.org/tdm/tdm11.htm
- Bicycle strategies elasticity data were obtained from: Technical Appendices, Moving Cooler, An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions, Cambridge Systematics, October 2009

LOCAL MEASURES

Electric/Natural Gas Measures Methodology

Electricity consumption accounts for about 25% of citywide greenhouse gas emissions, while natural gas accounts for about 17%. Because approximately 80% of electricity use and 90% of natural gas use is associated with buildings, many of the measures included in the City of San Diego CMAP target building energy use.

The City of San Diego CMAP includes 8 measures to reduce emissions from the electricity and natural gas categories. The following provides details about the data and methods used to calculate the energy and greenhouse gas emissions reductions.

Residential Efficiency Retrofits

The residential sector in the City of San Diego accounts for about 30% of electricity use and 33% of natural gas use. Much of this consumption is associated with existing buildings. This measure estimates the energy and greenhouse gas reductions associated with implementing energy efficiency retrofits in single family and multi-family homes.

- **Participation Rate and Average Energy Savings** – The CMAP assumes that 10% of existing single-family homes are retrofit to reduce energy use by 30% per unit and 15% of multifamily homes are retrofit to reduce energy use by 20% per unit by 2020. By 2035, the CMAP assumes that 25% of existing single-family homes are retrofit for an energy savings of 30% per unit and 30% of multifamily homes are retrofit for an energy savings of 20% per unit.
- **Pool of Homes for Retrofits** – It is assumed that all houses in San Diego County are eligible to be retrofit regardless of age. So, the target of reaching 10% means that 10% of all homes in the City of San Diego are retrofit.
- **Energy Reductions Calculation**- Energy reductions are calculated as a percentage of average residential energy consumption. The average residential electricity and natural gas consumption value is converted to million British thermal units (MMBTU) and combined to create a normalized energy consumption value. Reductions are calculated by taking a percentage of the normalized MMBTU value and then divided between electric and gas based on an average allocation between the two of 40% electric and 60% natural gas.

Sources:

- California Public Utilities Commission Database for Energy Efficient Resources (DEER), available at http://www.energy.ca.gov/deer/.
- Berkeley Residential Energy Conservation Ordinance, available at http://www.ci.berkeley.ca.us/ContentDisplay.aspx?id=16030.
- Meeting AB 32 - Cost-Effective Green House Gas Reductions in the Residential Sector. CONSOL, August 2008, available at http://www.consol.ws/studies.php.
- Critical Cooling, SPUR, February 2009, available at http://www.spur.org/publications/library/report/critical_cooling)

Commercial Efficiency Retrofits

The commercial sector accounts for 43% of electricity use and 25% of natural gas use in the City of San Diego. Much of this is associated with existing buildings. This measure estimates the energy and greenhouse gas reductions associated with implementing energy efficiency retrofits in commercial buildings.

- **Participation Rate and Average Energy Savings** – The CMAP assumes that 10% of commercial building space (square footage) is retrofit to reduce energy use by 15% per square foot by 2020, and 25% of existing square footage is retrofit for an energy savings of 15% per unit by 2035.
- **Percentage of Commercial Area that Can be Retrofit** – CMAP calculations assumes that all commercial area in San Diego County is eligible to be retrofit regardless of age. So, the target of reaching 10% means that 10% of all commercial square footage in the City of San Diego is retrofit.
- **Energy Reductions Calculation**- Energy reductions are calculated as a percentage of average commercial energy consumption per square foot. The average commercial electricity and natural gas consumption value is converted to million British thermal units (MMBTU) and combined to create a normalized energy consumption value. Reductions are calculated by taking a percentage of the normalized MMBTU value and then divided between electric and gas based on an average allocation between the two of   70% electric and 30% natural gas.

Sources

- SDG&E Standard Performance Contract program data for 2006 and 2007.
- California Public Utilities Commission Database for Energy Efficient Resources (DEER), available at http://www.energy.ca.gov/deer/.

Commercial Retro-commissioning

The California Energy Commission defines retro-commissioning as the process of "systematically investigat[ing] the operation of a building's energy consuming equipment to detect, diagnose, and correct faults in the installation and operation of commercial building energy systems." Retro-commissioning is typically only done in commercial buildings and is analogous to a tune up for a car.

- **Participation Rate and Average Energy Savings** – The CMAP assumes that 10% of all commercial building space (square footage) is retro-commissioned to reduce average energy use by 15% by 2020, and 25% of commercial space achieves a 15% reduction by 2035.
- **Percentage of Commercial Area that Can be Retro-commissioned** – The calculation assumes that all commercial building space in the City of San Diego is eligible to be retro-commissioned regardless of age.
- **Energy Reductions Calculation**- Energy reductions are calculated as a percentage of average commercial energy consumption per square foot. The average commercial electricity and natural gas consumption value is converted to

million British thermal units (MMBTU) and combined to create a normalized energy consumption value. Reductions are calculated by taking a percentage of the normalized MMBTU value and then divided between electric and gas based on an average allocation between the two of 70% electric and 30% natural gas.

Sources

- The Cost-Effectiveness of Commercial Building Commissioning: A Meta-Analysis of Energy and Non-Energy Impacts in Existing Buildings and New Construction in the United States, available at http://eetd.lbl.gov/emills/pubs/pdf/cx-costs-benefits.pdf
- CEC Options for Energy Efficiency in Existing Buildings - http://www.energy.ca.gov/2005publications/CEC-400-2005-039/CEC-400-2005-039-CMF.PDF.

New Construction Efficiency (Residential and Commercial)

California has strong building energy standards, many local governments require or encourage new construction projects to exceed these standards. This measure estimates the incremental greenhouse gas reductions from exceeding statewide standards. For the residential sector, the total greenhouse gas reduction value includes both single family and multifamily dwellings. Note that this measure only estimates the incremental greenhouse gas reductions associated with requirements that are better than statewide building energy codes; energy reductions from statewide standards are described below in the Statewide Measures section.

- **Participation Rate –** CMAP calculations assume that 15% of residential and commercial projects participate through 2016 and then 100% of projects participate through 2020.
- **Average Energy Savings** – The CMAP assumes that all new residential and commercial construction reduces energy savings to a level that is equivalent to 15% better than Title 24 requirements.
- **Energy Reductions Calculation**- Energy reductions are calculated as a percentage of average energy consumption per square foot for commercial and per unit for residential. The average electricity and natural gas consumption value is converted to million British thermal units (MMBTU) and combined to create a normalized energy consumption value. Reductions are calculated by taking a percentage of the normalized MMBTU value and then divided between electric and gas based on an average allocation between the two: 70% electric and 30% natural gas for commercial and 40% electric and 60% natural gas.
- **Energy Covered by Building Energy Standards** – Calculations assume that for commercial projects 60% of electricity and 70% of natural gas usage is subject to Title 24 requirements. For residential projects, it is assumed that 30% of electricity and 85% of natural gas is subject to Title 24 requirements.
- **Rate of New Construction** – For residential projects, it is assumed that single family homes are built at a rate of 1% of the total number of residential units in

2010, declining to 0.5% in 2020 and multifamily are built at a rate of 1% of total residential unit in 2010 and 2.2% in 2035.

- **Zero Energy Homes by 2020** – Calculations estimate emission reductions through 2020, assuming that by 2020 a zero energy home regulation will be in place and that there is not incremental emissions reduction from local policy.

Sources:

- California Energy Commission Residential Appliance Saturation Survey, available at http://www.energy.ca.gov/appliances/rass/
- California Energy Commission Commercial End Use Study California Energy Commission, available at http://www.energy.ca.gov/ceus/
- San Diego Association of Governments population and housing projections, SANDAG Data Warehouse, available at http://datawarehouse.sandag.org/

Residential Solar Water Heating Retrofit

On January 21, 2010, the CPUC approved a Decision creating the CSI-Thermal Program, which allocates significant funding to promote solar water heating (SWH) through a program of direct financial incentives to retail customers, training for installers and building inspectors, and a statewide marketing campaign. Assumptions used to estimate the emission reductions from solar water heaters are provided below.

- **Participation Rate** – The CMAP assumes that 5% of existing single-family homes install solar water heaters by 2020 and 15% by 2035.
- **Ratio of Electric and Natural Gas Water Heaters** – The CMAP estimate assumes that solar water heaters are installed in combination with both electric and natural gas water heaters. We further assume that 60% of the systems offset natural gas water heaters; 40% offset electric water heaters.
- **Energy Savings** – Based on Itron's evaluation study of CCSE Solar Water Heating Pilot Program, we assume that the annual energy reduction is 117 therms for a natural gas water heater, 2,700 kWh for an electric.
- **Useful Life** – Estimates assumes a useful life of 25 years for solar water heaters.
- **Single Family Housing Only** – The estimates here only calculates the effect of solar water heaters on single-family homes.

Sources

- CSI Solar Water Heating Pilot Program Final Evaluation Report, Itron. March 2011, available at http://energycenter.org/index.php/incentive-programs/solar-water-heating/swhpp-documents/doc_download/727-swh-pilot-program-itron-final-evaluation-report.
- CPUC Decision 10-01-022 (January 21, 2010), available at http://docs.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/112748.htm.

Commercial Solar Water Heating

On average, commercial customers use about 30% of their natural gas energy to heat water in the San Diego region. This measure estimates the impact of installing solar water heaters.

- **Natural Gas Only** – The CMAP estimates assume that in the commercial sector, solar water heaters will offset natural gas only.
- **Percentage of Total Water Heating Energy Covered** – The CMAP assumes that 5% of all the natural gas used to heat water in 2020 and 15% in 2035 is affected by solar water heating.
- **Energy Reduction** – A reduction of 50% of natural gas use for both 2020 and 2035 is assumed.

Sources

- Commercial End Use Survey, California Energy Commission, 2006 (CEC-400-2006-005-1), available at http://www.energy.ca.gov/ceus/.
- CSI Solar Water Heating Pilot Program Final Evaluation Report, Itron. March 2011, available at http://energycenter.org/index.php/incentive-programs/solar-water-heating/swhpp-documents/doc_download/727-swh-pilot-program-itron-final-evaluation-report.

Clean and Efficient Distributed Generation - Photovoltaics

The California Solar Initiative provides financial incentives for electric customers to install photovoltaics system on their homes and businesses.

- **Total Installed Capacity** – The CMAP assumes that in 2020 there will be 50 MW of photovoltaic capacity on homes in the City of San Diego and 200 MW by 2035. For commercial buildings, the value is 150 MW in 2020 and 350 MW in 2035.
- **Capacity Factor** – Calculations assume a capacity factor of 20% to calculate the energy production of solar photovoltaics.
- **Useful Life** – We assume that photovoltaics have a useful life of 25 years.
- **Decline in Energy Production** – Calculations a1% per year decline in energy production due to module degradation.

Sources

- CSI Single-Installation Cost Effectiveness Tool, ES, August 2010, available at http://ethree.com/documents/CSI/CSI%20Individual%20Installation%20Tool%203_11_2011.xls
- CA solar initiative California Solar Statistics, available at http://www.californiasolarstatistics.ca.gov/.
- Galen Barbose, Naïm Darghouth, and Ryan Wiser, Tracking the Sun III: The installed cost of Photovoltaics in the US from 1998-2010, Lawrence Berkeley

Laboratory, December 2010, available at http://eetd.lbl.gov/ea/emp/reports/lbnl-4121e.pdf.

Clean and Efficient Distributed Generation - Cogeneration

Cogeneration is typically more efficient than large centralized power plants because it uses waste heat for another useful purpose (e.g., heating or cooling water). Consequently, greenhouse gas emissions from cogeneration are lower per unit of energy than other types of generation using natural gas. Emissions reductions are calculated by multiplying the total amount of energy produced by cogeneration capacity by an emissions savings rate (lbs/MWh).

- **Total Installed Capacity** – The CMAP assumes that in 2020 there will be 150 MW of cogeneration capacity in the City of San Diego and 250 MW by 2035.
- **Capacity Factor** – CMAP estimates use an average capacity factor of 80% to calculate electricity production. This value represents the weighted average of capacity factors for the estimate additions by size (MW).
- **Emissions Savings Rate** – Calculations use an average emissions savings rate of 264 lbs/MWh, which is derived by taking an average emissions rate for combined cycle natural gas power plants and subtracting an average emissions rate for cogeneration.

Sources:

- E3 Modeling inputs for New CHP Built in 2008 and 2020, available at www.ethree.com/GHG/New%20CHP%20Data.032408.xls
- *Assessment of California CHP Market and Policy Options for Increased Penetration,* EPRI, Palo Alto, CA, California Energy Commission, Sacramento, CA: 2005, available at http://www.energy.ca.gov/2005publications/CEC-500-2005-173/CEC-500-2005-173.PDF
- Darrow, Ken, Bruce Hedman, Anne Hampson. 2009. *Combined Heat and Power Market Assessment.* California Energy Commission, PIER Program. CEC-500-2009-094-D, available at http://www.energy.ca.gov/2009publications/CEC-500-2009-094/CEC-500-2009-094-D.PDF
- SDG&E Cogeneration and Small Power Production Report, available at http://www2.sdge.com/srac/Jan_Jun_2011_Final.xls
- California Energy Commission Power Plant Database, available at http://energyalmanac.ca.gov/powerplants/POWER_PLANTS.XLS

Water Use Efficiency

The water conservation goal for the City of San Diego according to SB 7X is to achieve a daily per capita of 142 gallons in 2020. The City target for 2035 is to achieve 30% per capita reduction from the average baseline in 1996-2005 of 116 gallons.

- **Energy Reduction** – The energy reduction from water use reduction is calculated on the basis of the most recent energy intensity data associated with the four of the five stages of water supply to the City (CEC 2006). These stages are: water supply and conveyance, water treatment, water distribution, end-use, and wastewater treatment. Water supply and conveyance is not included as the emissions from this are also not included in the City's inventory. End-use emissions are likewise not included because they are accounted for in the electricity and natural gas emissions. The remaining stages are assumed to be within the geographical jurisdiction of the region and representative of the stages that water supplied to the City must go through. Each stage uses a different intensity of energy (see below). The CMAP assumes that the City of San Diego achieves the energy reduction from these stages according to the water consumption goals set forth in SB 7X (142 gallons per capita per day) by 2020 and 30% below the average baseline 1996-2005 in 2035.
- **Water Consumption Levels** –The estimated 2008 per capita use in the City was 147 gallons. This includes residential, commercial, industrial, institutional and irrigational uses as well as system losses. The projected BAU level is 151 gallons in 2020 and 152 gallons in 2035.
- **Energy Intensity of Water** – The energy intensities for Southern California used were obtained from the latest (2006) CEC report on energy use in California. End-use was not included, as it is included in the electricity and natural gas sectors of the CMAP. Table 3 provides the energy intensity factors used to estimate water-related GHG reductions in the CMAP.

Table 3 Energy Intensity of Water for City of San Diego

Category	Kilowatt-hours per/Acre-foot
Water Treatment	9,727
Wastewater Treatment	1,272
Water Distribution	111

- **Greenhouse Gas Intensity of Electricity** – To estimate the greenhouse gas impacts of reducing water use, we assumed a greenhouse gas intensity of electricity of 600 lbs/MWh in 2020 and 500 lbs/MWh in 2035.

Sources:

- Urban Water Management Plan 2010: Table 3-10 on total water use and projections; Table 3-12 for Base Daily per Capita Water Use 10-15 Year Ranges; Table 7, end use breakdown of energy intensity of water uses. Available at: http://www.sdcwa.org/uwmp

- Ronnie Cohen, Barry Nelson, and Gary Wolff, Energy Down the Drain: The Hidden Costs of California's Water Supply. NRDC and The Pacific Institute, 2004. Available at http://www.nrdc.org/water/conservation/edrain/edrain.pdf
- California Energy Commission 2005. California's Water-Energy Relationship, California Energy Commission. CEC-700-2005-011-SF.
- Navigant Consulting, Inc. 2006. *Refining Estimates of Water-Related Energy Use in California.* California Energy Commission, PIER Industrial/Agricultural/Water End Use Energy Efficiency Program. CEC-500-2006-118.

City Facility Efficiency Retrofits

- **Energy Reduction** – The CMAP sets a target of retrofitting existing City facilities and infrastructure to achieve an overall energy savings of 20% by 2020 and 30% by 2035.
- **City Energy Data** – The City of San Diego provided electricity and natural gas consumption data for City operations.
- **Energy Reductions Calculation**- Energy reductions are calculated as a percentage of average commercial energy consumption per square foot. The average commercial electricity and natural gas consumption value is converted to million British Thermal Units (MMBTU) and combined to create a normalized energy consumption value. Reductions are calculated by taking a percentage of the normalized MMBTU value and then divided between electric and gas based on an average allocation between the two of 70% electric and 30% natural gas.

TRANSPORTATION CATEGORY

On-road transportation accounts for 53% of all City GHG emissions. Eight (8) on-road transportation measures and one land use measures affecting transportation (community smart growth plans) were assessed for GHG reduction based on existing regulatory mandates. The greatest reductions arise from federal and state mandates for vehicle fuel economy, low carbon fuel and land-use changes.

Measures Contained in SB 375

The City of San Diego will benefit from local measures that are part of the Sustainable Communities Strategy (SCS) adopted under the California Senate Bill 375. SB 375 requires that the region achieve a GHG reduction per capita from personal miles driven (passenger cars and light duty trucks) of 7% in 2020 and 13% in 2035 compared with the value in 2005. The measures that will be part of the SB 375 SCS Strategy have been described by SANDAG and include: voluntary measures based on incentives for telecommute, carpools, subsidies for vanpools, buspools, and safe routes to schools to encourage walking to school; bottleneck relief projects such as increase in miles of freeway lanes to reduce fuel inefficient congestion; increase in miles of high occupancy vehicle lanes and freeway tolls; increase in the price of parking; bicycle lane increases

and pedestrian zone improvements; smart growth and population density increases; and mass transit use increases. The most significant of these measures are described below.

However, the following measures are NOT included within the SB 375 emissions reduction amount and are provided separately below (Other Transportation Measures) in order to better differentiate measures over which the City has jurisdiction or better identify the effect of mass transit use within the City:

- Land use related to smart growth including population density within the City
- The portion of the regional parking pricing program over which the City has jurisdiction
- Bicycle infrastructure improvements within the City
- Mass transit increases within the City.

The per capita regional SB 375 GHG reduction amounts were scaled to the City level by population.

Telecommute

This voluntary incentive based measure is included in the SB 375 reduction amount.

- **Percentage Jobs Eligible for Telecommute** - 33% of all jobs in the county
- **Percentage of Workers with Eligible Jobs that Choose to Telecommute** -- Not all eligible workers choose to telecommute. The current level is estimated as 10% of the eligible jobs in the county.
- **Number of Days Telecommuted** - A typical worker with a telecommutable job telecommutes twice per week. Several large software companies, such as IBM, have employees telecommuting on average 4 days per week, resulting in greatly reduced need for office space, thus costs

Vanpools

GHG reductions due to vanpools are included in the SB 375 reductions. Vanpools are taxpayer (through SANDAG) subsidized dedicated vans operated by private entities and used for commuting from residential areas directly to the workplace and back. There are over 700 vanpools in operation in San Diego County, most covering large commute distances, such as from Temecula to San Diego city. Similar incentive programs are to be available to encourage carpools and buspools

- **Average one-way distance:** 56 miles.
- **Current average persons per vanpool**: 8.3
- **Monthly vanpool subsidy:** $400 to providers.
- **Monthly fee**: Vanpoolers pay up to $120 in fees.

Bottleneck Relief Projects

Bottleneck relief projects include high occupancy vehicle toll lanes as well as other toll lanes, and freeway expansion for congestion relief. Both are measures included in the

SB 375 reductions to achieve GHG reductions from which the City of San Diego will benefit. GHG reductions from freeway expansion comes from short-term changes to the speed profile on freeways. The addition of freeway lanes in congested areas and peak hours allows traffic flow to harmonize, and speeds to change from very low (less than 15 mph) to more fuel-efficient levels between 40 and 65 mph.

- **Congestion relief**: freeway expansion on 132 miles of congested freeway by 2030.
- **High Occupancy Vehicle lanes and Toll (HOT) lanes** : 80 miles

Source

SANDAG Regional Transportation Plan 2050, Chapter 3, Sustainable Communities Strategy, available at:
http://www.sandag.org/index.asp?projectid=349&fuseaction=projects.detail

SANDAG Board Meeting, July 9, 2010, Item 3, SB 375 Implementation, available at:
http://www.sandag.org/index.asp?committeeid=31&fuseaction=committees.detail - mSched

Other Transportation Measures

The following measures are not included with the above SB 375 reductions: Mass Transit, Parking Fee Increases, Bicycle Lane increases, and Smart Growth/Population Density increases. Smart Growth/population Density Increase is described under "Land Use-Transportation". Other non-SB 375 measures described here are Preferred Parking for EVs, Reduction in Parking Spaces, Conversion of Municipal Fleet to EVs, and Increase in Electric Vehicle Miles Driven.

Mass Transit

- **Percentage commuters using mass transit** - Currently (2010) about 5.3% of commuters, SANDAG expects this value to increase to 7.8% in 2020 and 10.1% in 2035 by increasing the transit frequency, providing incentives, and adding some routes.

Source

SANDAG Regional Transportation Plan 2050, Chapter 3, Sustainable Communities Strategy, Final Environmental Impact Report, Appendix F-1, October 2011, available at:
http://www.sandag.org/index.asp?projectid=349&fuseaction=projects.detail

Parking fee increases

Increasing parking fees for residential and commercial uses has been shown to decrease the use of vehicles in those areas. Parking fee increases and the resulting GHG

reductions were based on research-based best estimates of the number of parking spaces in the City metropolitan area over which the City has jurisdiction.

- **Average daily parking rates**: increase from $20 per day in metropolitan area in 2008 to $24 in 2020 and $30 in 2035
- **Number of parking spaces under city jurisdiction**: 80,000 in both 2020 and 2035
- **Elasticity of parking pricing with VMT**: 0.1

Source

SANDAG, Regional Transportation Plan 2050, available at:
http://www.sandag.org/index.asp?projectid=349&fuseaction=projects.detail

Preferred Parking for EVs

By encouraging EV use, the average daily commute by conventional GHG -emitting vehicles would be avoided and replaced by zero emission vehicles.

- **Preferred Parking for EVs**: 10%, 20% of all metropolitan area parking spaces in 2020, 2035 respectively
- **Miles commute avoided by conventional vehicles per day**: 25

Parking space reductions

Reducing parking spaces in metropolitan areas encourages alternative transportation, walking and biking, thus reducing VMTs.

- **Reduction in number of parking spaces**: 10% less in 2020, 20% less in 2035
- **Number of spaces under City jurisdiction**: 80,000 in in 2020 and 2035
- **Miles commute avoided by conventional vehicles per day**: 25

Convert Municipal Passenger Vehicle Fleet to EV

Converting the municipal passenger vehicle fleet gradually to EVs will reduce gasoline use, thus GHGs. The City of San Diego provided current use of gasoline consumption. It was assumed that there would be no changes in 2020 and 2035 to this gasoline demand.

- **Gasoline use**: 90% reduction in gasoline use 2020, 90% reduction in gasoline use in 2035, baseline year 2008

Source

City of San Diego for fleet gasoline consumption

Bicycle Infrastructure

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SANDAG's regional bicycle strategy includes increasing the number of bicycle lanes conducive to commuter use. A portion of these lanes is within City boundaries and is thus expected to reduce miles commuted by conventional vehicles to provide GHG reductions within the City. The City Bicycle Master Plan assumes a 279% increase in bicycle commuters by 2022. Based on bicycle commute elasticities (Moving Cooler 2009), this would require an estimated 4 miles/square miles then.

- **Miles of bicycle lanes**: Increase from 1.1 lane miles per square mile today in the City to 4 lane miles per square mile in 2020 and 8 lane miles per square mile in 2035.
- **Miles vehicle commute avoided**: 8 miles per day

Source

SANDAG, communication, for average bicycle commute distance in City of San Diego

SANDAG Plan Report, City of San Diego Bicycle Master Plan, Alta Consulting, 2002.

Moving Cooler: An Analysis of Transportation Strategies for Reducing Greenhouse Gas Emissions, Cambridge Systematics, July 2009.

Percentage Electric Vehicles

Increasing the number of electric vehicles in the personal vehicle fleet helps to reduce emissions, particularly as renewable energy supplies a larger portion of electricity. The default percentage of miles driven by electric vehicles were calculated from a California Energy Commission projection of electricity use for electric vehicles in 2010, 2020 and 2035 in the SDG&E service territory. Electricity values were converted to miles using the following assumptions.

- **Electricity Equivalent of Gasoline** – CMAP estimated the percentage of miles that will be driven by electric vehicles using 33.7 kWh/gallon.
- **Miles per Gallon Equivalent** - Estimates assumed that electric vehicles would achieve 100-150 miles per gallon equivalent over the study period.
- **Percent driven by EV miles**: 4% of personal miles driven in 2020, 11% of personal miles driven in 2035. These are therefore the miles avoided by conventional fuel vehicles.

Source

- Kavalec, Chris and Tom Gorin, 2009. California Energy Demand 2010-2020, Adopted Forecast. California Energy Commission. CEC-200-2009-012-CMF, available at http://www.energy.ca.gov/2009publications/CEC-200-2009-012/index.html.
- US. Department of Energy, US Environmental Protection Agency, 2011. Fuel Economy Guide – Model Year 2011. DOE/EE-0333. http://www.fueleconomy.gov/feg/feg2011.pdf.

LAND USE - TRANSPORTATION

Smart Growth

Smart growth refers, among others, to land development that involves re-zoning land uses to enable more efficient urban mobility. It is assumed that all smart growth projects planned in the City's communities will be implemented by the target years. Smart growth projects reflect increases in mixed-use zones and population density increases, leading to reduced VMT.

- **Population density increase**: 12% in 2020, 27% in 2035, compared with 2008
- **Elasticity of walking due to population density increase**: 0.07
- **Elasticity of transit use due to population density increase**: 0.07

Source

Demographics and Other Data, available at:
http://www.sandag.org/index.asp?classid=26&fuseaction=home.classhomePopulation

SANDAG, Regional Transportation Plan 2050, Chapter 3, available at:
http://www.sandag.org/index.asp?projectid=349&fuseaction=projects.detail

More information about community smart growth plans are found at:
http://www.sandag.org/index.asp?projectid=296&fuseaction=projects.detail

WASTE

Divert Waste and Increase Capture Waste Gases

The IPCC Waste model was used by City staff to produce landfill methane and N20 emissions, which were converted to CO_2e by multiplying by the GWPs. Waste disposed is forecast from 2011-2035 including diversion from 2022 as Miramar closes, and any additional waste is recycled, sent to Sycamore or diverted outside City of SD. Landfill gas capture data were provided by the City.

Wastewater emissions data and BAU calculations and results were provided by the City.

- **Landfill methane capture rate**: 80% capture of total estimated landfill gases in 2020 and 2035.
- **Wastewater treatment capture rate**: 98% capture of potential estimated wastewater treatment gases in 2020 and 2035.

STATE AND FEDERAL MEASURES

State Electric and Natural Gas Measures

Emissions reductions associated with the renewable portfolio standard is included the City of San Diego CMAP. As the percentage of renewable electricity delivered to residents and businesses increases, the greenhouse gas intensity of electricity decreases.

California Renewable Portfolio Standard

Legislation signed into law in 2011 requires California's electric utilities to provide 33% of electricity supplies from renewable sources. This requirement is known as the Renewable Portfolio Standard (RPS). Increasing the level of renewable energy supply lowers the greenhouse gas intensity of electricity (lbs/MWh). The following assumptions are used to calculate the emissions reductions expected from the Renewable Portfolio Standard.

- **RPS Targets** – It is assumed that SDG&E will reach the 33% target by 2020 and maintains that level through 2035.
- **Electricity Sales as a Baseline for RPS Calculation** – Estimates use electricity sales as the baseline to calculate the emissions impact of renewable supply in the region. The level of sales is adjusted to account for energy efficiency measures included in the City of San Diego CMAP.
- **Renewable Energy has No Emissions** – For simplicity, calculations here assume that all renewable energy supply emits no greenhouse gases.

Sources

- Renewable Portfolio Standard Bill (SBX 1 2), available at http://www.leginfo.ca.gov/pub/11-12/bill/sen/sb_0001-0050/sbx1_2_bill_20110412_chaptered.pdf.

State and Federal Transportation Measures

Federal Corporate Fuel Economy Standards adopted by the federal government will improve the fuel efficiency of the fleet of cars and light-duty trucks in the City of San Diego. Furthermore, California has adopted a Low-carbon Fuel Standard that seeks to reduce the greenhouse gas intensity of transportation fuels. Both of these policies will reduce overall emissions in the City of San Diego.

Pavley I and CAFÉ standards: Passenger Vehicle and Light Duty Truck Fuel Economy

The California AB 1493 (2002, Pavley I) required manufacturers to conform to stringent tailpipe emissions standards for greenhouse gases equivalent to achieving a significant increase in fuel efficiency of cars and light duty trucks. In May 2009, the federal Corporate Average Fuel Economy Standards were adjusted to conform to California's Pavley I equivalent. California then amended AB 1493 (Pavley I) to conform to the federal CAFE standard from 2012 to 2016, on condition that it receives a waiver to set

its own vehicle standards after 2016 and enforce its standards for model years 2009 to 2011. CAFE mandates the sales-weighted average fuel economy (in mpg) of the passenger cars and light-duty trucks for a manufacturer's fleet. New passenger vehicles must meet a sales weighted average of 39 mpg, light duty trucks a value of 30 mpg, resulting in an average 34.5 mpg for the fleet if it is met only by fuel economy improvements. This corresponds to a CO_2e target of 250 grams/mile in 2016 from those vehicles.

- **Date Achieved** - The CMAP assumes that Pavley I or CAFE 2016 standards for new passenger vehicles are achieved in 2020
- **Improvements after 2020** – It is assumed that there will be no further fuel economy or tailpipe emission standards in 2035.

Source:

- Average Fuel Economy Standards, Passenger Cars and Light Trucks, MY 2011; Final Rule is available at http://www.nhtsa.gov/fuel-economy.

Low Carbon Fuel Standard (LCFS)

The California LCFS (2010) requires that a regulated party reduce the carbon intensity per Mega Joule of its transportation fuel (gasoline and diesel) by 10% in 2020. A regulated party is any supplier of transportation fuel, including importers. Electricity suppliers are considered regulated parties only if they elect to provide credit to fuel distributors. At this time, there are no monitoring reports of the status of use of electricity credits for the LCFS to indicate the magnitude of carbon intensity reduction that electric vehicles will play in 2020. Therefore, for CMAP purposes, miles driven by electric vehicles are not considered a part of this standard. CMAP also assumes no new low carbon fuel mandates in 2035. It is possible that the interaction of this standard with electric vehicles will have to be re-visited in the future.

Source:

Information about the LCFS program is available at:
http://www.arb.ca.gov/fuels/lcfs/lcfs.htm

BUSINESS-AS-USUAL PROJECTION METHODOLOGY

A business-as-usual projection was calculated to estimate the level of emissions in 2020 and 2035 if no action were taken. This estimate assumes that no new policies are adopted and that there is no further activity on existing policies. This estimate becomes the baseline from which emissions from all measures is subtracted to determine if CMAP targets are reached. There are a number of assumptions that are used to estimate future projections. The following sections provide information on the methodology used to project emissions and the assumptions included in those calculates.

On Road Transportation

The City of San Diego provided vehicle miles traveled (VMT) data for the years 1990, 2004, 2007, 2008 and 2009. Forecasts for VMT for 2010, 2020 and 2035 were made based on San Diego Association of Government (SANDAG) population growth rates for the City.

EMFAC 2007 Series 12 input files for the region were provided by SANDAG for the years 2010, 2020 and 2035. EMFAC 2007 was run in burden mode to provide CO2e for the region for the years 2020 and 2035. This was converted to a CO2e/VMT for the region, which was assumed to represent the CO2e/VMT for the City. City emissions projections were calculated with this CO2e/VMT factor and the City's forecasted VMT.

The BAU projections for on-road transportation do not include emissions reductions due to the Pavely I/CAFÉ fuel economy standards or the Low Carbon Fuel Standard, or the miles driven by electric vehicles.

Electricity

The City of San Diego provided historical electricity consumption values for 1990, 2004, and 2007-2009. To project City of San Diego values, we used California Energy Commission (CEC) forecasts for the San Diego Gas and Electric (SDG&E) service territory through 2020 (linear projections to 2035) to develop an average ratio between City of San Diego total consumption and SDG&E consumption for years 2007-2009.

This ratio value was multiplied by the CEC forecast through 2035 to get an estimate of the City of SD consumption levels. The ratio value used (42%) is roughly equivalent to the ratio of franchise fee revenue from the City of San Diego to the overall SDG&E territory for years 2006 and 2007.

To estimate emissions from electricity, projected consumption levels were multiplied by the greenhouse intensity value for electricity (lbs/MWh) used by the City of San Diego to calculate electric emissions in 2009. The value used was 720 lbs/MWh.

Forecast Assumptions

The following provides a list of programs and policies that are included in the electricity forecast.

- Renewable Portfolio Standard – 11.9% of retail electricity sales in 2010
  - GHG Intensity of electricity 722 lbs/MWh
  - Assumes direct access providers have the same GHG intensity
- New Residential Building Standards – 2005 Title 24 (effective 10-1-05)

- New Commercial Buildings Standards – 2008 Title 24 (effective 1-1-10)
- Appliance Standards – those in effect in 2010
- AB 1109 Lighting Standards – electric savings through 2020
- Utility Energy Efficiency Programs – electric savings from 2010-2012 program cycle

Natural Gas

The City of San Diego provided historical natural gas consumption values for 1990, 2004, and 2007-2009. To project City of San Diego values, we used California Energy Commission (CEC) forecasts for the San Diego Gas and Electric (SDG&E) service territory through 2020 (linear projections to 2035) to develop an average ratio between City of San Diego total consumption and SDG&E consumption for years 2007-2009.

This ratio value was multiplied by the CEC forecast through 2035 to get an estimate of the City of SD consumption levels. Note that the gas data used by the City of San Diego to calculate their inventory includes gas used for electric generation using cogeneration, therefore the ratio of City-provided consumption levels is higher than the ratio (about 75%) without natural gas for cogeneration (about 45%).

To estimate emissions from electricity projected consumption levels were multiplied by a conversion factor of 0.0053052 MMT CO2e/million therms. This is equivalent to 5.31 metric tons of CO2E per therm.

Forecast Assumptions

The following provides a list of programs and policies that are included in the natural gas forecast.

- New Residential Building Standards – 2005 Title 24 (effective 10-1-05)
- New Commercial Buildings Standards – 2008 Title 24 (effective 1-1-10)
- Appliance Standards – those in effect in 2010
- Utility Energy Efficiency Programs – therms savings from 2009-2012 program cycle

Waste

The City of San Diego provided both landfill and wastewater treatment emissions for 1990, 2004, 2007, and 2007-2009, and forecasts for 2020 and 2035. For landfill emissions, the City of San Diego used the IPCC Waste Model to calculate landfill methane and N20 emissions, which were converted to CO2e by multiplying by their global warming potentials. Changes to waste disposal inputs as well as closure of the Miramar landfill from 2022 were taken into account for forecasts for 2035. The business as usual projection for 2020 and 2035 includes the current approximately 70% of the total potential landfill gas emissions captured today.

Wastewater emissions were calculated by the City based on EPIC's 2008 GHG Inventory methodology. This used a methane or nitrous oxide emissions factor per person developed by the California Air Resources Board for the region. The emissions factor for methane was 9,855 grams per capita, for nitrous oxide 95 grams per capita. The BAU for 2020 and 2035 includes the approximately 71% of wastewater treatment emissions captured today.

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Sources:

IPCC Waste Model, available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol5.html

EPIC Greenhouse Gas Inventory, Waste, available at: http://www.sandiego.edu/epic/ghginventory/

Water

The BAU projections for the City's water use are available in the County Water Authority's Urban Water Management Plan (UWMP, 2010). The 2008 per capita value of 147 gallons was interpolated between the 2005 and 2010 actual water use data in the UWMP 2010. The BAU per capita daily value 2020 is 151 gallons. The 2035 BAU per capita daily value is 152 gallons.

Sources:

Table 3-10, Urban Water Management Plan 2010 available at: http://www.sdcwa.org/uwmp

Appendix III: Cost Effectiveness Methodology Documentation

This document provides information about the data, methodologies, and sources used to estimate the cost of a subset of measures to reduce greenhouse gas included in the City of San Diego Climate Mitigation and Adaptation Plan (CMAP). Table 1 provides a summary of the cost, which is shown in the net present value in 2010 dollars per metric ton of carbon dioxide equivalent ($2010/MT CO_2e) for the measures analyzed.

Table 1. Summary Table of CMAP Mitigation Strategies Cost Effectiveness ($2010/MT CO_2e)

Cost Effectiveness of CMAP Measures ($2010/MT CO_2e)

Electric/Natural Gas Measures	2020
Commercial Retro-Commissioning	($193)
Commercial Efficiency Retrofits	$42
Residential Solar Water Heating Retrofit - SF	$72
Residential Efficiency Retrofit - MF	$100
Residential Photovoltaics	$175
Commercial Photovoltaics	$327
Residential Efficiency Retrofit - SF	$596

Transportation Measures	2020
Mass Transit with health benefits	($3,373)
Traffic light retiming with health benefits	($457)
Traffic light retiming	($341)
Roundabouts	($340)
Parking Fee Strategy	$9
Prefered Parking for Evs	$15
Mass Transit	$1,809
Bicycle Strategy	$40,864

Note: Because of the difference in methodology, no 2010 values are available for transportation measures.

ELECTRIC AND NATURAL GAS MEASURES

The City of San Diego CMAP estimated cost effectiveness for 7 electric and natural gas measures. The following provides details about the data and methods used to the cost per metric ton of greenhouse gas reductions from these 7 measures.

Overall Methodology

Cost estimates for electric and natural gas measures were derived by calculating the net present value of each measure and dividing this value by the total greenhouse gas emissions reductions realized from each measure. The net present value calculation discounts to the present (at 5%) the capital expenditure, future operational costs, and the future stream of cost savings from energy savings. The resulting dollar-per-metric-ton value normalizes the cost so they can be compared across all measures.

Calculations for electric and natural gas measures take into account direct costs and benefits and do not account for health or environmental costs and benefits.

Residential Efficiency Retrofits

The residential sector in the City of San Diego accounts for about 30% of electricity use and 33% of natural gas use. Much of this consumption is associated with existing buildings. This measure estimates the energy and greenhouse gas reductions associated with implementing energy efficiency retrofits in single family and multi-family homes.

- **Cost of Residential Energy Reductions** – The CMAP cost calculations assume that the cost of a residential retrofit is $13,000 in 2010 and 2020 for single-family units and $4,000 in 2010 and 2020 for multifamily units.
- **Energy Reduction from Retrofits** – Energy reductions from retrofits are assumed to be 30% in 2010 and 2020 for single-family units and 20% in 2010 and 2020 for multifamily units.
- **Useful Life -** Cost calculations are made assuming a useful life of 15 years.

Sources:

- California Center for Sustainable Energy. Single-family cost and energy reduction estimates for 2010 are rules of thumb based on a limited number of projects in the Energy Upgrade California Program.
- Heschong Mahone Group. Multi-family cost and energy reduction estimates for 2010 are rules of thumb based on a limited number of multi-family retrofits projects.

Commercial Efficiency Retrofits

The commercial sector accounts for 43% of electricity use and 25% of natural gas use in the City of San Diego. Much of this is associated with existing buildings. This measure estimates the energy and greenhouse gas reductions associated with implementing energy efficiency retrofits in commercial buildings.

- **Cost of Commercial Retrofits** –A 2005 Lawrence Berkeley National Laboratory (LBNL) study of ESCO projects found an average cost for a range of commercial energy retrofits of $2.32/ft^2 across all sectors. This value is comparable to values cited in an analysis of commercial efficiency projects related to New York City's Energy Leasing Legislation, which showed a range of costs from $2.00/ft^2 - $2.25/ft^2 for a 20% energy reduction. A review of commercial retrofit project conducted in the SDG&E territory as part of the Savings Bid Program in 2006 and 2007 found a weighted average cost of electricity efficiency projects to be $0.75/kWh and for natural gas efficiency $4.35 per therm. Converting these values to a dollar-per-square foot value, based on the participation rates used to determine greenhouse gas reduction levels, results in a value of about $2.00/ft^2. CMAP cost calculations are based on $2.25/ft^2 for a 15% energy reduction in 2010 and 2020.
- **Energy Reduction from Commercial Retrofits** – The LBNL study found a median total energy reduction of about of 15 kBTU/ft2, or 18% of the average commercial energy consumption in 2010 of about 82 kBTU/ft^2. CMAP cost calculations assumed a 15% energy reduction in 2010 and 2035.
- **Useful Life** – Cost calculations are made assuming a useful life of 12 years.

Sources

- SDG&E Standard Performance Contract program data for 2006 and 2007.
- New York City's Office of Long-Term Planning and Sustainability (OLTPS), A Model Energy Aligned Lease Provision, City of New York Planning Division. Available at http://www.nyc.gov/html/planyc2030/html/about/ggbp.shtml#more.
- Goldman, C., N. Hopper, J. Osborn, and T. Singer. Review of U.S. ESCO Industry Market Trends: An Empirical Analysis of Project Data. LBNL-52320. January 2005. Available at http://eetd.lbl.gov/ea/emp/reports/52320.pdf.
- Goldman, C., J. Osborn and N. Hopper, LBNL, and T. Singer, NAESCO, Market Trends in the U.S. ESCO Industry: Results from the NAESCO Database Project LBNL-49601. May 2002 Available at http://eetd.lbl.gov/ea/emp/reports/50304.pdf.

Commercial Retro-commissioning

The California Energy Commission defines retro-commissioning as the process of "systematically investigat[ing] the operation of a building's energy consuming equipment to detect, diagnose, and correct faults in the installation and operation of commercial building energy systems." Retro-commissioning is typically only done in commercial buildings and is analogous to a tune up for a car.

- **Cost of Retro-Commissioning** – The average participant cost in 2010 was assumed to be $0.55 per square foot (ft^2). This values is based two sources: Lawrence Berkeley National Laboratory estimated average retro-commissioning costs to be $0.41 per square foot, the California Energy Commission estimated those costs to be $0.68 based on projects completed in California. The $0.55/ft^2 cost value is conservative given the Lawrence Berkeley National Laboratory median cost estimate

was $0.27/ft^2$. For 2020, it is assumed that the average cost for retro-commissioning will be $0.45/ft^{2.}$

- **Energy Reductions Calculation**- The average energy reduction in 2010 from retro-commissioning was assumed to be 15%. This value is based on the same two sources referenced above: Lawrence Berkeley National Laboratory estimates average energy savings to be 19%, the California Energy Commission estimates energy savings to be 13%. To be conservative, the value used for average reductions was slightly lower than the average between the two sources but equal to the median energy reduction estimate from Lawrence Berkelely National Laboratory. The average energy reduction value used for 2020 calculations remained 15%.
- **Useful Life** – Cost calculations assumed that the useful life of retro-commissioning energy reductions was 10 years.

Sources

- Cost-effectiveness of Commercial-Buildings Commissioning. A Meta-Analysis of Energy and Non-Energy Impacts in Existing Buildings and New Construction in the United States, Lawrence Berkeley National Laboratory, LBNL-56637, 2004. Available at eetd.lbl.gov/emills/pubs/pdf/cx-costs-benefits.pdf.
- CEC Options for Energy Efficiency in Existing Buildings - http://www.energy.ca.gov/2005publications/CEC-400-2005-039/CEC-400-2005-039-CMF.PDF.

Residential Solar Water Heating Retrofit (Single-family Units Only)

On January 21, 2010, the CPUC approved a Decision creating the CSI-Thermal Program, which allocates significant funding to promote solar water heating (SWH) through a program of direct financial incentives to retail customers, training for installers and building inspectors, and a statewide marketing campaign. Assumptions used to estimate the emission reductions from solar water heaters are provided below.

- **Cost of Solar Water Heater Installation –** CMAP cost calculations are based on an average installation cost of $6,500 for single-family units in 2010 and $6,000 in 2020.   The 2010 value is based on a 2011 Itron evaluation of California Center for Sustainable Energy's (CCSE) Solar Water Heating Pilot Program. The 2020 value assumes a slight reduction in installation cost over time as more systems are installed in the City of San Diego.
- **Ratio of Electric and Natural Gas Water Heaters** – The CMAP estimate assumes that solar water heaters are installed in combination with both electric and natural gas water heaters. We further assume that 60% of the systems offset natural gas water heaters; 40% offset electric water heaters.
- **Energy Savings** – Based on Itron's evaluation, we assume that the average annual energy reduction is 117 therms for a natural gas water heater, 2,700 kWh for an electric.
- **Useful Life** – Estimates assumes a useful life of 25 years for solar water heaters.

Sources

- CSI Solar Water Heating Pilot Program Final Evaluation Report, Itron. March 2011, available at http://energycenter.org/index.php/incentive-programs/solar-water-heating/swhpp-documents/doc_download/727-swh-pilot-program-itron-final-evaluation-report.
- CPUC Decision 10-01-022 (January 21, 2010), available at http://docs.cpuc.ca.gov/PUBLISHED/FINAL_DECISION/112748.htm.

Clean and Efficient Distributed Generation –Photovoltaics

The California Solar Initiative provides financial incentives for electric customers to install photovoltaics system on their homes and businesses.

- **Installation Cost** – CMAP cost calculations assume that the cost of installed residential photovoltaics was $8.00/watt in 2010 and will be $6.00/watt in 2020, about a 3% annual decrease. For commercial systems, the calculations assume an installed cost of $7.00/watt in 2010 and $5.00/watt in 2020, about a 3.5% annual decrease.
- **Capacity Factor** – Calculations assume a capacity factor of 20% to calculate the energy production of solar photovoltaics.
- **Useful Life** – The CMAP assumes that photovoltaics have a useful life of 25 years.
- **Decline in Energy Production** – Calculations a1% per year decline in energy production due to module degradation.
- **Operations and Maintenance** – Cost calculations include $0.01/kWh for operations and maintenance and an inverter replacement every 10 years. Inverter costs are assumed at $0.75/watt in 2010 and $0.50 in 2020.

Sources

- CSI Single-Installation Cost Effectiveness Tool, ES, August 2010, available at http://ethree.com/documents/CSI/CSI%20Individual%20Installation%20Tool%203_11_2011.xls
- CA solar initiative California Solar Statistics, available at http://www.californiasolarstatistics.ca.gov/.
- Galen Barbose, Naïm Darghouth, Ryan Wiser, and Joachim Seel, Tracking the Sun IV:An Historical Summary of the Installed Cost of Photovoltaics in the United States from 1990 to 2010. Lawrence Berkeley Laboratory, December 2010, available at http://eetd.lbl.gov/ea/ems/reports/lbnl-5047e.pdf.

TRANSPORTATION MEASURES

On-road transportation accounted for approximately 53% of all greenhouse gas emissions in the City of San Diego in 2008. The City of San Diego CMAP estimated costs

for 6 measures. For two measures, mass transit and signal re-timing, separate cost benefits are provided that also include monetized health benefits.

Mass Transit

Mass transit costs were based on SANDAG's estimates to increase the mode share from the current 5% all day for commuters in the region to 7.8% in 2020 and 10.1% in 2035. We assume the same changes scaled to the City commuter population. The cost to achieve the new percentage in each target year is the additional costs incurred by SANDAG for transit compared with the previous period, 1999-2010. The fuel cost saved by individuals was subtracted from the SANDAG costs. SANDAG costs are net of revenues from bus fares. The cost of a gallon of fuel was held at $3.50.

Recent estimates of monetized health benefits (Litman, 2010) from mass transit use are included as a separate cost per metric ton item in the cost effectiveness calculations. Including the estimated health benefits results in change in cost effectiveness of use of mass transit from positive to negative.

Sources

- SANDAG RTP 2020, page 327, Table 12-5 2020 Transit Plan Projected Costs and Revenues, for estimates of the operating and capital costs for transit for 1999-2010.

- SANDAG RTP 2050, Appendices, page A-26, Table A.6 Major Transit Expenditures - Revenue Constrained Plan, for the cost estimates from 2010-2020 and 2020-2035.
- 2050 Regional Transportation Plan/ Sustainable Communities Strategy, Final Environmental Impact Report, Appendices A-F, October 2011, Appendix F-1.
- Todd Litman, Evaluating Public Transportation Health Benefits, *14 June 2010, Victoria Transport Policy Institute,* For *The American Public Transportation Association, (www.vtpi.org/thbc.xls), Table 6.*

Parking Fee Strategy

Increasing parking fees for residential and commercial uses has been shown to decrease the use of vehicles in those areas. Parking fee increases and the resulting greenhouse gas reductions were applied to research-based best estimates of the number of parking spaces in the City metropolitan area over which the City has jurisdiction.

Fees obtained from the increase are assumed offset by the revenue to the City, making this a revenue neutral measure, except for minimal administrative costs for the City to operate the system.

Source

- SANDAG, Regional Transportation Plan 2050, available at: http://www.sandag.org/index.asp?projectid=349&fuseaction=projects.detail

Bicycle Strategy

SANDAG's regional bicycle strategy includes increasing the number of bicycle lanes conducive to commuter use. A portion of these lanes is within City boundaries and is thus expected to reduce miles commuted by conventional vehicles to provide GHG reductions within the City.

Costs were based on SANDAG's estimates of the cost for Class I and II per bicycle lane mile. Fuel savings by individuals amount to the equivalent of 8 miles per day avoided by use of a conventional vehicle. The fuel economy of personal vehicles in 2020 was estimated as 23.93 in 2020 and 27.42 in 2035. The price of gasoline was held at $3.50 per gallon.

Sources

- SANDAG, San Diego Regional Bike Plan, Riding to 2050, Unit Costs Used for Estimating Costs of Regional Bicycle Network, Table 6.1, at http://www.sandag.org/index.asp?projectid=353&fuseaction=projects.detail

- SANDAG, communication, for average bicycle commute distance in City of San Diego

Preferred Parking for Electric Vehicles

By reserving 10% and 20% of the total parking spaces in the City for electric vehicles, no additional costs are incurred except for minimal City administrative costs. Enforcement costs are assumed offset by parking fees. An administrative cost of $8 per space was assumed.

Source

- http://legacy.signonsandiego.com/uniontrib/20080601/news_1n1pkmain.html# for typical enforcement, administrative costs and fines revenues estimates in the City of San Diego.

Signal Retiming

By harmonizing speeds, traffic light retiming reduce emissions and crash damages. The cost per signal retiming was estimated from a SANDAG study of 1993, which comprehensively addressed the potential for signal retiming in the whole region. Low and high costs for installation and engineering costs are also provided in that report. High cost estimates were used for CMAP. Capital costs are offset by individual fuel savings.

The SANDAG study also provides time savings and air pollution cost benefits. These additional savings are included as a second separate estimate for cost per metric ton of GHG avoided.

Source

6-6-12

- SANDAG, Traffic Signal Optimization Program, April 1994, page 4-17, Appendix C Exhibit 5.2, provided by SANDAG; and costs of pollutant emissions reductions and public health effects.

Roundabouts

Like synchronized traffic lights, roundabouts at intersections in place of stop signs or traffic signals lead to reduced emissions and reduced crash damages.

Capital costs for roundabouts are offset over their lifetime by fuel savings.

The net costs do <u>not</u> include costs avoided from traffic lights potentially replaced by roundabouts, time savings, air pollution savings, or crash reduction benefits.

Source

- Continued Reliance on Traffic Signals: The Cost of Missed Opportunities to Improve Traffic Flow and Safety at Urban Intersections, Casey Bergh, Richard A. Retting, Edward Myers. September 2005. Insurance Institute for Highway Safety, at www.iihs.org.
- City of San Diego Manager's Report, Feb 4, 2004, Report No 04-028, for discussions of cost of Traffic Management Plan for the Bird Rock area of La Jolla.

Appendix IV: Participation Rates for CMAP Measures Chart

CMAP Measures	Inputs		Basis for Participation Rates
Local Measures - Electric/Natural Gas	**2020**	**2035**	
Commercial Retro-Commissioning			
Average Energy Reduction (%)	15%	15%	Based on (1) The Cost-Effectiveness of Commercial Building Commissioning: A Meta-Analysis of Energy and Non-Energy Impacts in Existing Buildings and New Construction in the United States, available at http://eetd.lbl.gov/emills/pubs/pdf/cx-costs-benefits.pdf,and (2) CEC Options for Energy Efficiency in Existing Buildings - http://www.energy.ca.gov/2005publications/CEC-400-2005-039/CEC-400-2005-039-CMF.PDF.
% Commercial SF	10%	25%	Based on California Long-Term Energy Efficiency Strategic Plan.
Commercial Efficiency Retrofits			
Energy Reduction (%/unit)	15%	15%	Based on energy reduction levels from SDG&E Standard Performance Contract Program.
Area Retrofit (% of SF)	10%	25%	Based on policy direction from the California Public Utilities Commission to increase the number of deep retrofits and California Long-Term Energy Efficiency Strategic Plan.
Residential Efficiency Retrofit - Single Family (SF)			
Energy Reduction (%/unit)	30%	30%	Based on Energy Upgrade California program participation.
Number of Units Retrofit (% total units)	10%	25%	Based on policy direction from the California Public Utilities Commission to increase the number of deep retrofits and California Long-Term Energy Efficiency Strategic Plan.
Residential Efficiency Retrofit - Multi Family			
Energy Reduction (%/unit)	20%	20%	Based on City of San Diego multi-family efficiency program participation.
Number of Units Retrofit (% total units)	15%	30%	Based on policy direction from the California Public Utilities Commission to increase the number of deep retrofits and California Long-Term Energy Efficiency Strategic Plan
Residential Solar Water Heating Retrofit - SF			
Number of Units (% total units)	5%	15%	Based on incentives available through the California Solar Initiative (CSI). Energy savings based on CSI evaluations.
Commercial Solar Water Heating Retrofit			
Reduction in water heating energy	50%	50%	Based on average energy reduction due to solar water heating.
% commercial water heating energy affected	5%	15%	Based on incentives available through the California Solar Initiative.
Residential PV			
Total Capacity (MW)	50	200	Based on current trends and availability of incentives through 2016.
Commercial PV			
Total Capacity (MW)	150	350	Based on current trends and availability of incentives through 2016.

Cogeneration (MW)			
Total Capacity (MW)	150	250	Based on a prorated share of technical potential for the SDG&E territory.
CMAP Measures	**Inputs**		**Basis for Participation Rates**
Residential New Construction			
% better than T24	15%		Based on California Green Building Code and California Long-Term Energy Efficiency Strategic Plan to achieve net zero energy homes by 2020.
Participation Rate after 2015	100%		Assumes that this level is required.
Commercial New Construction			
% better than T24	15%		Based on California Green Building Code and California Long-Term Energy Efficiency Strategic Plan to achieve net zero energy homes by 2030.
Participation Rate after 2015	100%		Assumes that this level is required.
Water Use Efficiency			
Gal/person/day	142	116	2020 values based on 2010 Urban Water Management Plan, goal adopted for the City of San Diego under SB 7X. 2035 value Represents a 30% per capita reduction from average baseline 1996-2005 from UWMP, viewed as an acceptable goal by stakeholders
City Building Efficiency			
% reduction in total energy consumption	20%	30%	Based on historic energy reductions in City of San Diego operations
Local Measures - Transportation	**2020**	**2035**	
Mass Transit			
% mode share	8%	10%	SANDAG RTP 2050 forecast for the region applied to the City
Bicycle Infrastructure			
Bicycle lanes per square mile	4	8	City of San Diego Bicycle Master Plan 2002 assumes a 270% increase in bicycle commuters within 20 years. To achieve this would require nearly tripling the bicycle lane miles per square mile in 2020 from current (2010) estimated 1.4 lanes/square mile. 4 miles in 2020 is then a reasonable expectation.
Parking - reduce spaces			
% of total reduced Metro area	10%	20%	As advised by City of San Diego
Parking - preferred parking for EVs			
% reserved for electric vehicles	10%	20%	As advised by City of San Diego
Parking - Increased fees			
$ per day	24	30	2020 value from SANDAG RTP 2050 SCS Scenario measure for Metro region. 2035 value extrapolated from SANDAG RTP 2050 SCS Scenario measure for Metro region

CMAP Measures	Inputs		Basis for Participation Rates
City of San Diego Share of SB 375 Reductions (Includes telecommute, carpool, vanpool, bus pool, bottleneck relief, HOV/HOT lanes, safe routes to school)			Based on and extrapolated from SANDAG's Sustainable Communities Strategy.
% of target achieved	100%	100%	Based on SANDAG's estimates for SB 375 emission reduction targets scaled to City
Signal timing and roundabouts			
Number of signals and roundabouts, each	15	20	Based on discussion with City traffic management as feasible
Electric Vehicles			
% miles driven of cars and light duty truck miles (private vehicle miles)	4%	11%	Based on CEC projection of electricity use for electric vehicles in 2020. 2035 value is linear extrapolation from 2022 value.
Convert municipal fleet to EV			
% reduction gasoline fuel	90%	90%	As advised by City of San Diego
Local Measures - Land Use	**2020**	**2035**	
Smart Growth			
% increase in population density from 2010	12%	27%	SANDAG RTP 2050 Growth Forecast
Local Measures – Waste	**2020**	**2035**	
Divert Trash and Capture Landfill Gas			
% landfill gas capture	80%	80%	As advised by City of San Diego and state mandate
% wastewater gas capture	98%	98%	As advised by City of San Diego as planned and feasible
State/Federal Measures	**2020**	**2035**	
Renewable Portfolio Standard			
% of sales that is renewable	33%	33%	Statutory requirement. See CA Public Utilities Code § 399.11 et seq. and CA Public Resources Code § 25740 et seq., as adopted in SBx1-2 on 4-12-11.
Pavley I (approximately equivalent to CAFÉ standards in mpg)			
MPG for New Passenger Vehicles	34.5	34.5	Based on federal CAFÉ standards
Low-Carbon Fuel Standard			
% reduction in carbon intensity	10%	10%	Low-Carbon Fuel Standard requirements as adopted by the California Air Resources Board applied to the fuel consumption of the City of San Diego.
CARB Tire Pressure Program			
% CARB goal achieved	100%	100%	Tire Pressure Program requirements as adopted by the California Air Resources Board applied to the City of San Diego
CARB Heavy Duty Vehicle Regulation			
% CARB goal achieved	100%	100%	Heavy Duty Vehicle Regulation requirements as adopted by the California Air Resources Board

Appendix V – City of San Diego Adaptation Economic Analysis

Krout & Associates

The Costs Come Before the Benefit

How much to adapt is an economic problem—how to allocate limited resources for climate adaptation strategies while also providing other necessary services. Decision-makers ask: What is the potential loss to local economies and communities from climate change? What is the cost to implement adaptation strategies? Will the benefits outweigh the costs?

For many areas at risk, the potential loss from climate change can be reduced or eliminated by adaptation strategies. However, without adequate data, perceived threats from climate change may lead to implementation of strategies without understanding of the short- and long-term impacts to the local economy. Reactive adaptation strategies implemented by the public agencies, private businesses, and residents may protect individual assets (i.e. homes and businesses), but may not address the local economy's cumulative needs. Reactive adaptation measures will in many cases be more costly than proactive, planned strategies. A homeowner or business may take their own actions to adapt, without public interventions, but under the guidance existing public policy. These spontaneous and autonomous actions are vital to the overall effort to adapt to a changing climate; however, the private sector is primarily market driven, and as a result, will act in there own best interest. A disjointed approach to adaptation can lead to economic inefficiencies, or worse, limited or no protection for public resources such as water and open space.

As a result, it is necessary for the public decision-makers to consider the possible risks and implementation costs from a holistic perspective. Consideration should be given not only to the economic implications of adaptation strategies, but also the environmental and the social impacts. Ecosystems already suffer environmental degradation and climate change will pose an additional stresses. Climate adaptation strategies should consider the value (benefit) of amenities and resources from an economic and social-value perspective. Additionally, exposure to climate change poses different risks to different groups of people. In general, temperature increases have a larger detrimental effect on older individual and the physically ill as compared to the general population. Low-income households are more likely to live in floodplains and susceptible to flood. While an adaptation strategy may provide beneficial economic impacts to a subset of the community, the costs may be unequally distributed leading to hardship for economically disadvantaged populations.

There are numerous methods and models available to perform an economic analysis of climate adaptation strategies. The intent is not to define a detailed model, nor to evaluate a specific adaptation strategy, but rather to illustrate the general framework of analysis. The framework describes the general steps to perform the analysis. The general framework should provide a

roadmap to assess the local risk from climate change and help identify a cost-effective set of adaptation strategies.

Economic Framework for Assessment

The economic framework illustrates a multi-step process for quantitatively evaluating a set of climate adaptation strategies. The first step is to estimate the potential loss from climate change to vulnerable sectors. The second step is to determine the cost to protect and preserve those vulnerable sectors. The final step is to develop detailed cost-benefit assessments of climate adaptation strategies.

1. Estimate potential losses
2. Calculate implementation cost of adaptation strategies
3. Perform cost-benefit analyses for proposed adaptation strategies

With limited resources, it is not always feasible to implement every climate adaptation strategy. A quantitative evaluation of the strategies should be considered the baseline for discussion. The section concludes with a discussion of the economic implications that should be considered when evaluating adaptation strategies. In combination, the understanding of quantitative and qualitative data can provide clarity for decision-makers considering climate adaptation strategies.

Step 1. Estimate potential loss from a climate change event

What is the value of what may be lost to vulnerable sectors by a climate change event? Put another way, what is the benefit of the vulnerable sector to the economy? The evaluation of the potential loss depends upon calculations of climate change risk and the asset value within the market sectors vulnerable to climate change. This risk is defined as the likelihood of an event occurring and the magnitude of consequences should that event occur (NPCC). Forecasts of the frequency, magnitude, and sector vulnerability are traditionally forecast with the use of specialized climate change probability models. The potential loss is calculated as a function of the severity and frequency of the climate hazard, the value of assets exposed to the hazard, and the vulnerability of those assets to the hazard.

The role of the economic analysis is to assess the economic impacts to assets. Local businesses; cultural and recreational centers; and the underlying physical infrastructure (including water and transportation networks) provide tangible and intangible value or benefits (economically, environmentally, and socially) to a community. By first understanding the value, the potential losses from a climate-change related event (by not implementing adaptation strategies), can be calculated. Assessment of vulnerable sectors should incorporate forecasted changes in the economy and regional demographics to account for the risk of climate change on a evolving economic and population base.

An estimation of infrastructure and other tangible resource values can be calculated using the replacement cost and adjusting for inflation (all else held equal). The cost of replacing intangible resources is more difficult. Environmental quality and social cohesion are complex resources to apply a monetary value, yet methods do exist to provide estimation[1]. By measuring the overall value or benefit, decision-makers can understand the total economic, environmental and/or social loss to the local community if a significant climatic event occurred.

Step 2. Calculate implementation costs of adaptation strategies

Cost for adaptation strategies include the labor and resource costs necessary to implement a proposed strategy. From an economic perspective, the strategies can be divided into three general categories for cost assessment: Maintenance and operations, capital investment including redevelopment, and regulatory and climate change policy. Timing for implementation of specific adaptation strategies within these categories is an important cost consideration as well. Maintenance and operations costs will occur in the short and long-term; however, capital improvements may decrease maintenance costs over the long-term if implemented in the short-term.

The asset valuation is highly dependent on the associated risk in terms of understanding the possible level of frequency and magnitude. When estimating the economic value of an asset, we assume the entire benefit may be lost from a climate change event. The probability is low that an entire sector would be eliminated. It is more likely that only a proportion of the value will affected and over a limited period of time. Therefore, when estimating costs, loss of the entire sector is a baseline, with the understanding that the actual costs will depend on the frequency, magnitude, and overall vulnerability of the sector.

Step 3. Perform cost-benefit analyses for proposed adaptation strategies

The costs of adaptation and potential losses from future climate change are used in cost-benefit analyses to examine the impact of climate change. Through cost-benefit analysis, where the cost-benefit ratio is a measurement of the capital and operating expenditures against total economic benefit, decision-makers can compare, quantitatively, the financial impact of climate adaptation measures. A simple terms, the most cost-effective adaptation strategy is one where:

Adaptation Costs < Potential Losses from Climate Change (without Adaptation)

Take for example a local park that would be hypothetically inundated by water from increased rainfall and flooding. Assume in this example that the cost to replace the park facilities is $200,

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[1] A series of methods exist for benefit estimation including the travel-cost method, hedonic pricing, and contingent valuation.

the monetary value, of the park[2]. Assume that decision-makers can select from one of two strategies: Upgrade of existing storm drains or development of new bio-swales to divert water. Assume implementation of the first adaptation strategy costs $150 (up-front) to prevent or reduce damages from climate change events by $200. Now assume the second adaptation strategy, bio-swales, costs $100 (up-front) to prevent or reduce damages by $200. In this simplified example, the second scenario has a greater benefit-to-cost ratio, and therefore could be the recommended strategy.

Cost-benefit approaches are typically more complex than the example above. The models traditionally attempt to normalize costs and benefits over time. Future expected costs and benefits are converted into a "net present value" amount using a selected discount rate. The discount rate used for climate change adaptation strategies is highly subjective. Risk associated with possible losses from climate change events can be calculated via probability models and incorporated into the discount rate.

Economic Assessment Considerations

Adaptation is not free. On the other end, the investment potential is unlimited to hedge against all possible losses. To be cost-effective, adaptation strategies should:

Identify cost savings through planned projects

"Planning for climate change today is less expensive than rebuilding an entire network after a catastrophe." – Plan NYC

Proactive planning for climate adaptation is less expensive the reactive, emergency measures after a severe climate action event. Through planning, decision-makers can determine the overall feasibility and applicability of the most cost-effective adaptation strategies.

Prioritize hard and soft adaptation strategies

Adaption strategies can be categorized in to "hard" and "soft". Hard adaptation strategies usually imply the use of specific technologies and actions involving capital goods, such as dikes, seawalls and reinforced buildings, whereas "soft" adaptation strategies focus on information, capacity building, policy and strategy development, and institutional arrangements (World Bank).

Hard adaptation strategies (e.g., capital improvement) is often more expensive than soft adaptation strategies. At the same time, they may also be less flexible in the long term if forecasting of future climate impacts is over- or under-estimated. Soft adaptation strategies (e.g., policy reform) are often less costly in monetary terms, more flexible and tend to focus on

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[2] This analysis ignores the underlying opportunity cost of the land. The assumption is the land use would remain constant.

the affected people rather than the affected land, should be considered and combined with hard options.

III. Reduce risk exposure and mitigate residual losses with insurance

The total cost of climate change is the sum of the cost of adaptation, mitigation, and any residual potential losses not averted by the mitigation or adaptation strategies. It is not normally cost-effective to implement adaptation or mitigation strategies that completely reduce the potential losses from a climate change event. Insurance reduces the exposure to climate change risk, by covering the residual losses, and should be incorporated into the cost-benefit analyses of climate adaptation strategies.